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A Case for Teaching Development Philosophy to Science and Engineering Undergraduates in Zimbabwe's State Universities

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Abstract

The paper highlights some concepts of socio-economic relevance which have negatively impacted the Education system and introduces a Development Philosophy concept that is required during the training of Engineering, Social and Physical Science Undergraduates in Zimbabwe's State Universities. As a nation we have done well in establishing a sound university education system, but the focus has since shifted from demand for university education to demand for a vibrant economy that provides sufficient employment to its graduates. The progress that has been made in the higher education sector has been phenomenal but still falls short of economic expectations in a number of sectors. It is fact that by and large, the nature of the subjects taught in Sub-Sahara African Universities including our state universities are primarily within the traditional Science and Engineering disciplines and are regularly modified to be in line with global trends in social, technological and scientific advancement. The economic challenges facing Zimbabwe and its State Universities now necessitate a new approach to university education that produces a different type of graduate that is empowered individually, corporately and nationally through a philosophical study of the relationships between economic development, skills, equipment, capital and resource utilization.

This paper also presents the basis for a course of action required for enhancing the education and human resource development in Sub-Saharan Africa, although the focus will be on Zimbabwe through a strategic process of aligning attitudes and understanding towards sustainable socio-economic growth using state universities and colleges. Globally, some national attitudes can be observed as follows:

- (I) Under "similar conditions" one nation will contemplate war with another nation over the death of one or two of its citizens whilst for another nation hundreds have to die before being forced to accept that there is a national disaster.*
- (Ii) In one nation a large piece of land is turned into a thriving economy whilst in another, similar land is turned into hazardous wasteland. These two precursors highlight strengths and weaknesses that can be embodied in public education systems in shaping socio-economic norms and values.*

Four simple mathematical models are developed to illustrate the relationship between Science, Engineering and Socio-Economic

development. These models should form the foundation required for the empowerment of the university and college student to effectively participate in an African economy.

Key Words: Development Philosophy

Definition: *Development Philosophy is a research and verification based process of aligning national attitudes and understanding towards sustainable socio-economic growth.*

Introduction

As we review the level of social and economic development in Sub-Saharan Africa during the pre-and post-independence periods we find that the responsibility of preparing and supporting people in positions either in government, business or society in general lies with the State Universities and State Colleges through the respective ministries of Higher Education. Quantitatively university and college expansion has been particularly impressive with university enrolments growing from 21,000 in 1960 to more than 430,000 in 1983. [1] It is also observed as fact that both quantitative and qualitative aspects of the education and socio-economic planning in most African states was done in Europe and America during the colonial or protectorate periods primarily for the benefit of the foreign economies. Primary research, whether it was in health, education, social sciences or physical sciences and the development of corporate and industrial systems were also initiated, or given the go-ahead in Europe and America. Suffice it therefore to mention that Post-independent African economies became beneficiaries of the results of the intellectual effort of individuals, public and private institutions of other countries. The weaknesses of such a scenario were never adequately analyzed due to structural deficiencies inherent in the political, educational and socio-economic structures. These deficiencies would only manifest themselves as symptoms of socio-economic development ineptitude in most post-independence African States including Zimbabwe as a result of genuine or intentional educational oversights.

Purpose and Objectives

The overall purpose of the paper is to acknowledge a post-colonial setting and present a few broad and deep developmental concepts and introduce them together with a mechanism for further investigation and application in post independence socio-economic setting. The paper is also designed to challenge the status-quo in Higher Education for further examination, study and conclusion by educators, scholars, employers and policy-makers.

The specific objectives of the paper are to:

- Repackage a few common place observations and knowledge, and present them in such a way as to create a fundamental base of ideas in our education system which will contribute to scholarly investigation and application of cultural and current socio-economic interactions with science and engineering education to address our socio-economic challenges. [2]
- Facilitate the development of curricula and programs for preparing development oriented social and physical scientists, engineers and technologists through State Universities, technical institutes and colleges.
- Facilitate a process to extricate ourselves from continued political and economic exploitation by the principal industrial nations and regions of the world, both traditional and emergent.

Weaknesses of Current Mode of Operation

The Education System and its Origins

The education systems developed during the colonial period and inherited by the African States at the time of independence were not designed to meet normal requirements of the new states during the period of self governance and economic expansion and were therefore inherently inadequate. Despite this inadequacy in the way Education was development in Sub-Saharan Africa, the overall progress achieved in African education has been phenomenal.

This progress since the days of independence in the early 1960's is now under severe strain and threat from economic pressures directly linked to the education system itself. This threat arises because the education systems in the African States did not adequately invest in the preparation and support of the people now in leadership positions either in government, business or society in general to fully appreciate the role of education in post independent Africa and the need for continuous funding of educational programs. The realization of this threat normally coincides with cutbacks in public spending on education in the face of national economic decline. Public spending on education in Africa dropped from US\$10 billion in 1980 to US\$8.9 billion in 1983. [1] These basic facts on one hand constrain the options available to policy makers and can impose further limitations in the education sector, yet on the other hand these same basic facts usher a unique opportunity to review the policy framework and align education policies with economic policies.

This policy review is necessitated by the fact that the education systems inherited by the African States at the time of independence were not designed to adequately meet the normal requirements of the new states during the period of self governance and economic expansion. It also has to

be fully appreciated that the education systems inherited by the African States at independence were by design offshoots of existing education systems and institutions in Europe and America supported by their respective public and private sectors.

Education and Employment Creation

In Africa, Education and Employment Creation are like players in different teams competing with each other on the socio-economic field. The reason why education and employment creation are in competition in Africa is historical and is directly related to the origins of these two concepts. As mentioned earlier the Education system in colonial Africa was meant to serve European and American Economic interests. Education and employment creation together with its intricacies like tools of trade and skills requirements were therefore terms better understood by the respective parties because of their socio-economic inter-relationships. Instead of being formidable team players complementing each other on the socio-economic playing field in post independent Sub-Sahara Africa, education and employment creation are increasingly being misunderstood and mismanaged. This misunderstanding has resulted in Africans using their hard-earned education to try and secure employment in foreign lands where "by some strange logic" the education and employment creation relationship seem to be complimentary on the socio-economic playing field.

The Education Triangle

The Education and Employment Creation relationship seem to be complimentary in foreign lands especially in Europe, America and Australia because of the consistent application of three Education principles namely Learning, Teaching and Application. The Education system is inherently a triangle of three equal and functional sides and for it to successfully play its role on the socio-economic playing field in any country; it must be made to fully function in all the three principal areas of Learning, Teaching and Application.

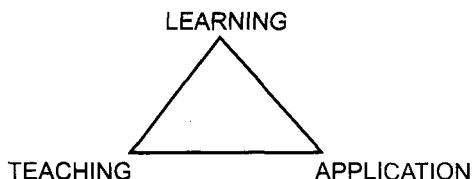


Fig. 1: The three functional sides of the Education system.

If the Education process is not made to fully function in these three areas, there will be disharmony and underperformance on the socio-economic playing field due to ill-prepared participants and poor knowledge of the

rules of the game.

Post Independence Sub-Saharan Africa has to appreciate that Education in this region apart from the Arabic influence, has its origins in Europe and America and goes far beyond the basic concepts of reading, writing and speaking capabilities. Education is a multi-faceted phenomenon that cuts across the fundamentals of human socio-economic development. When understood and applied in this manner, it facilitates mutual respect in the global village. The new approach to training undergraduates in State Universities and Colleges will also explore modern approaches to industrialization that are being adopted by the fast emerging economies and this is expected to offer opportunities to develop socio-economic strategies for Sub-Saharan Africa.

The International Donor Community in Education

The quantitative growth and expansion accompanied by the respective qualitative attributes in the development of educational systems is a direct function of national policy and the ability of the national economy to fund the education budget. Most African States can not fund the education budgets of their countries. The International Donor Community has played a pivotal role in funding some of the developments in educational systems and programs in Africa but the evaluation of the benefits and their sustainability has not been so evident from political and socio-economic standpoints.

Whilst the involvement of the International Donor Community in the development and funding of the educational systems and programs in Africa might be looked at favorably or unfavorably, the reality of the dilemma points to two areas of responsibility:

- (a) A strong national economy that can fund the education budget; and
- (b) An education system that empowers its nationals to effectively participate in national socio-economic development.

Whilst it might remain difficult to understand the real motives behind the objectives of some International Donor Communities in the Education Sector in Sub-Saharan Africa, concern has been raised that the underlying interests could be economic.

The Need for Policy Reform

Taking into account the progress, developments achieved and the outstanding challenges in both the Education and Economic sectors in post-independent Africa, it will be easy to see that difficult decisions on education policy reform can not be delayed any longer. [3] In the case of Zimbabwe, State Universities and Colleges are under-funded and their contribution to national development is being undermined by interrelated weaknesses as highlighted below:

- (a) Research in Higher Education is not directly linked to solving known socio-economic problems;
- (b) The quality of Research and Development shows unmistakable signs of deterioration and decay thereby challenging the effectiveness and understanding of the roles of such services;
- (c) Funding the Higher Education budget is now a problem for government;
- (d) The pattern of funding the Higher Education Budget demonstrates that it is economically not sustainable;
- (e) There is no Development Philosophy that cuts across national policies to facilitate the adequate preparation of undergraduates, companies and government departments to participate in the various socio-economic sectors.

Further analysis of the above weaknesses should facilitate policy reforms that seek to achieve the following objectives:

- (i) Improve relevance of Higher Education in the national economy;
- (ii) Create new revenue streams;
- (iii) Smooth the process of teaching Development Philosophy in State Universities and Colleges.

A Paradigm Shift is Required

In a socio-economic environment where the relationship between education, employment creation and socio-economic development are not easily comprehended in post independence Sub-Saharan Africa, it becomes imperative that perceptions of people in positions of authority need changing, more so in view of the weaknesses inherited at independence due to the structural deficiencies inherent in the political, educational and socio-economic structures prevailing during the respective periods.

Current thinking on education and employment creation needs to be aligned with socio-economic realities and global trends. Changing the way things are done with the intention of arresting the negative socio-economic trends in Zimbabwe and Sub-Saharan Africa requires the employment of Change Management and Structural Adjustment techniques which use proven methods that have been used successfully for elsewhere.[4] A paradigm shift is inevitable in the wake of a more assertive global economy.

Seedbeds of Development

In Zimbabwe, most of the older institutions within government and the private sector have infrastructure, facilities, equipment and literature that meet some of our development needs without the need of much additional funding. Education, in many respects operates in the reverse mode as it moves forward. This process is little understood by governments and industry in sub-Saharan Africa where "the old is associated with obsolescence and is condemned to the scrap heap". The Education system

and socio-economic development operate more efficiently on a premise shared by Abraham Lincoln that, to be clear of where one wants to get to, one needs to be sure of where they are at any particular moment and they need to ascertain where they came from. For the purpose of teaching Development Philosophy in State Universities, what will also be required, therefore, is a qualitative and quantitative analysis of the physical infrastructure, educational systems, economic linkages, knowledge and culture left behind by Europe and America, and its current state. This analysis should be a sufficient basis to identify support structures and systems that naturally complement current developmental efforts and initiatives. [3] [4]

The missing link or the gap, however, between the above opportunities and the national challenges is a development philosophy that commits the intellectual effort of our Undergraduates to resource utilization for national development in a planned, systematic and coordinated manner. Whilst Educational Reports may contain evaluations on the colonial legacy based on System and Technical Audits, it still remains to be demonstrated that these evaluations have been applied in a beneficial and sustainable manner.

The absence of this demonstration of proper evaluation and the full exploitation of benefits of the colonial legacy became possible and thus negatively influenced the pace of national socio-economic development because Zimbabwe and most African States south of the Sahara were not proactive in the development of long-term national strategies with the involvement of their State Universities and colleges. The traditional Developed World and the fast developing economies of the Eastern Countries are continuously evaluating, improving and implementing their national strategies which are aimed at exploiting Africa's resources (including those of Zimbabwe) into the unforeseeable future, for the development of their economies with the involvement of their universities and colleges.

A Development Philosophy ensures the full integration of the three faculties of Learning, Teaching and Application of the Education system during the training of undergraduates for the national Socio-Economic playing field. Without a Development Philosophy, Zimbabwe will continue to lose the usefulness of its vital human capital between the walls of lecture theatres, seminar rooms, laboratories, workshops and graduation halls to the advantage of the Developed World and the fast developing economies.

The Law of Conservation of Matter

National Resources and Colonialism

Zimbabwe had vast mineral resources, which should have been processed for the development of this nation but these resources have been in the main

exported for comparatively little benefit to the nation. Colonial trade was based on the supply of raw materials to Europe and America to drive the colonial economic machinery where the colonies were the suppliers of raw materials and secondary economic beneficiaries. This unbalanced partnership compounded by deficiencies in, or complete absence of a national Development Philosophy on the part of the former colonies, is responsible for the inadequate socio-economic infrastructure prevailing after independence. During this colonial period, complex infrastructure in the energy and power sectors, transport sector, building sector and industry in general, was built in UK, Europe and America using Zimbabwe's mineral resources. The total quantity of metal (iron, steel, aluminium, copper, nickel, gold etc) from colonial Africa, which is now embedded in the European and American economies runs into millions of tons. On the other hand, Zimbabwe and post-independent Sub-Sahara Africa and her future generations can lay no claim to any of those millions of tons of metal irrespective of the unreasonableness of the trade deals crafted during that period.

In Zimbabwe, there are however some reserves still remaining in some categories of minerals. These reserves are much lower now and yet the population in Zimbabwe will be on a steady increase. Whilst the trade figures and the mode of trade from the colonial period to date can be classified as historical, the exploitation, processing and utilization of the remaining resources including the potential for petroleum oil and natural gas, presents itself as an opportunity that should demand a very different approach from colonial or previous trade practices.

A Scientific Approach to Socio-Economic Development

In post-independent Sub-Saharan Africa, education, employment creation and socio-economic development do not seem to be directly related or interdependent. The absence of a demonstrable interdependence is reason for the deep rooted misconception that sustainable employment is only possible in foreign lands or through the hands of foreigners. This misconception is however, inevitable in view of the relatively similar social and economic conditioning that prevailed in Sub-Saharan Africa. It is this misconception that created and continues to create a regrettable imbalance between Learning, Teaching and Application to the detriment of sustainable socio-economic development.

This paper sheds some light in an otherwise sad and darkened area of socio-economic development of post-independent Sub-Saharan Africa by highlighting the fact that the relationship between education, employment creation and socio-economic development is deeply rooted in the sciences. The paper also highlights that it is the responsibility of State Universities and Colleges to propagate this light for the benefit of government, industry

and all sectors of the economy. Whilst socio-economic development is evaluated on the basis of the ability to supply goods and services on demand, the development of the required understanding of national development on the other hand rests with State Universities and Colleges and should focus on the scientific and economic treatment of matter, the material that everything in the universe is made of, for the socio-economic benefit of mankind.

In 1774 the great French chemist Lavoisier put forward the law of conservation of matter which forms the foundation of, not only all quantitative work in chemistry but also that of modern socio-economic development. It says that:

Whatever change that may take place in the distribution of matter, the total amount of it in the universe does not change.

[5] In other words, matter can neither be created nor destroyed, although it can be rearranged or recycled. Is it true? In the Chemistry laboratory a student can easily be convinced, because the learning process requires him/her to accept the statement as a hypothesis which should be proven in the laboratory during the course of his/her study. The same hypothesis presented to a miner on the Great Dyke or an officer in the Minerals Marketing Corporation of Zimbabwe (MMCZ) will result in a response which will most probably depend on whether they still remember the hypothesis from their school or college days and not necessarily in relation to their occupations. A casual consideration of the same question in the second scenario would most likely solicit a challenge to its relevance. You dig a hole and extract 10 tons of mineral ore and export it to the Far East. You cover up the hole; it certainly looks like Lavoisier's statement has no relevance here. In economic and development terms the statement means that once a resource leaves Zimbabwe or any African country and is destined for another country or another continent, Zimbabwe or any other African country that allows the movement of that resource loses the direct opportunity of using that resource for its own use for ever.

On further analysis it will be observed that the law of conservation of matter formed the foundation for all quantitative work in chemistry, whilst chemistry formed the foundation for quantitative work in metallurgy and modern manufacturing, whilst modern manufacturing philosophy attempts to satisfy the supply side of the economic equation. An informed re-look at Europe, America and the fast emerging economies, will enable us to see more clearly that science, engineering and socio-economic development are inextricably linked. The knowledge arising from this understanding on the part of post independent Sub-Saharan Africa should facilitate better insights into the World Trade and its exploitative practices and its impact on national development.

The Law of Conservation of Matter therefore forms a strong reference point on which the Development Philosophy is anchored. Whilst the treatment of socio-economic development through the use of scientific and mathematical models might be challenging, this is however inevitable because mathematics allows for the eventual quantification of benefits to the individual citizen in economic terms. Scientific treatment of socio-economic development is also unavoidable for Sub-Sahara Africa because desired outcomes can be designed in such a way as to safely avoid the repetition of history.

Mathematical Models for Socio-economic Development

We have looked at the relationship between post-independence African socio-economic problems, the problems of funding education systems and programs, and the need for an education system that empowers its nationals as they receive training in State Universities and Colleges so that they can positively contribute to the national socio-economic development activities. We have also seen how Lavoisier's law of conservation of matter is directly related to western and global economic strategies and practices.

It will also be observed that most post-independence African States also face broad similarities in the behaviour of their economies and the question to answer has been; what should they do next? Some have looked at the question from a thematic approach of education and employment with not so convincing results, whilst others have dared to be more truth-seeking and to the point:

"My own view really is that when we discuss problems of African development whether it is in education, agriculture, communication, industrialization etc. there are a lot of major problems which affect the African continent that could be tackled better if Africans were used even if you wanted to use outside experts because of their vast experience" (Mutumbuka, 1989).

How can all these relationships and ideas be reduced to mathematical models that are easy to understand and be incorporated into a Development Philosophy suitable for State University and College undergraduates? Some simple hypotheses are at the centre of the mathematical models introduced here and will be developed further into suitable course material for training purposes.

The simple hypothesis we will use to develop our students in State Universities and Colleges whilst developing their ability to process the natural resources and provide services on the continent is stated as follows, **"Economic Development (ED) is a function () of Human Skill available (S), the quality and type of equipment used (E), the working capital available (C), and the level of support, cooperation, motivation,**

timeliness of decisions etc. given and aggregated into an efficiency factor (k), in the processing of national resources." This relationship can be expressed mathematically as follows:

$$ED = (\text{Skill, Equipment, Capital})$$

$$= k \cdot S \cdot E \cdot C \quad \text{per-unit}$$

..... Equation 1

$$\text{Or, } = k \cdot S \cdot E \cdot C \cdot 100\%$$

Where, k= efficiency factor (0-1)

S= Skill (0-1)

E= Equipment (0-1)

C= Capital (0-1)

ED= Economic development

The adequacy or relevance of the skill, equipment and capital is evaluated on a scale of 0% to 100% or 0 to 1, so is the efficiency factor.

The level of Economic Development of a country is normally measured in terms of Gross National Product (GNP). From the above equation it therefore follows that the GNP of a country is a function of the available skills, equipment and capital used in processing the natural resources and production of goods and services in that country or from other countries.

This relationship can also be summarized as follows:

$$\text{GNP} = (\text{Skill, Equipment, Capital})$$

$$= k \cdot S \cdot E \cdot C \quad \text{..... Equation 2}$$

2

Skill: Skill in economic development terms is acquired through formal training in training institutions to enable a worker to achieve an economic efficiently. The impact of skills flight (brain-drain) can also be observed.

Equipment: These are tools, machines, clothes etc that worker needs to perform a particular job or activity.

Capital: This relates to money that is needed in an economic activity to enable that activity to subsequently make more money.

The Law of Conservation of Matter has its origins in Chemical Research and has facilitated scientific and technological progress through Research and Development (R & D) activities in the Physical Sciences for socio-economic benefits. It is a fact that the basic Economic activity is driven by

the supply and demand equation. The supply side of the economic equation on the other hand is driven by the ability to produce, whilst the ability to produce is driven by the ability to carry out successful Research and Development programs.

The above relationship can be summarized into an economic hypothesis which says: **The level of sustainability of Economic Contribution (EC) in any Economy that is dependent on its natural resources is a function of the number of Research and Development programs commercialized in any given period.**

The above hypothesis can be expressed as shown below.

$$EC = (\text{Total R\&D products commercialized})$$

This expression can be further developed into a mathematical equation that can be used to evaluate the direct contribution of R & D programs into the GNP of a country, as shown below.

..... Equation 3

Where n = Maximum number of R&D products commercialized per year.

P_i = Magnitude of the sector contribution to the national economy (GNP) that is being focused on by the i th R&D activity, e.g. electricity, Mining, Transport etc.

i = Probability of commercialization of the i th R&D product.

t_i = Target share for the i th R&D product.

The probability of commercialization, i , is a measure of how well the R & D programs are focused towards production of goods and services of a socio-economic value. The probability of commercialization, i , of any (i th) R&D product therefore depends on how effectively human skill, equipment and capital are employed in any program by government or an institution. It will be noticed that Probability of Commercialization i is equal to Economic Development (ED) in per unit terms and therefore requires no further treatment in this paper.

$$i = (\text{Skill, Equipment, Capital}) = k_i \cdot S_i \cdot E_i \cdot C_i \quad \text{..... Equation 4}$$

Where k_i is the efficiency factor (0-1) applying to any one R&D product.

The maximum possible value of ED and i is unity or 100% and is a three dimensional quantity, the volume of a cube. The aim of any country is therefore to make the three dimensional quantity as near unity (perfect) as possible through the provision of highly skilled professionals, relevant and adequate equipment, and adequate capital in a timely manner for the processing of its natural resources or resources from other countries

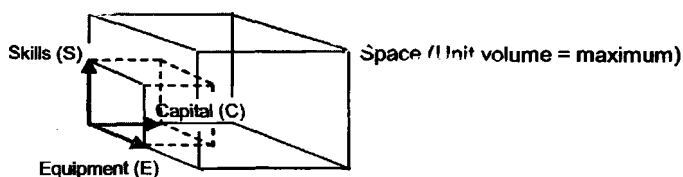


Fig. 2 The concept of Economic Development as a unit space

As an example if we assume that in a given R&D project, the skills level is 10% ($S=0.1$), Capital is 100% ($C=1$), Equipment is 100% ($E=1$) and Efficiency factor is 50% ($k=0.5$) then the probability of commercialization () is 0.05 per-unit or 5%.

It can be observed that it is not easy to achieve the unit cube or make an economy operate with 100% probability of commercialization of R&D products hence the need for strategy and continuous improvement in this area.

Conclusion

Zimbabweans have a colonial background but have taken bold initiatives to set up Commercial Banking services, Telecommunications Services and other services within and outside its borders. A formal strategy to empower its nationals to be keen socio-economic players will be a bold initiative that will ensure Zimbabwe of sustainable economic growth.

As Zimbabweans we are under pressure to demonstrate that we have a sustainable strategy or strategies to manage our recurrent socio-economic challenges. Whilst the concept of special Universities with a commercialization thrust is not new in Zimbabwe, some of the reasons for failure are the fundamentals of this paper. The fast emerging economies of the east are successfully applying the same concept because there was a readjustment of economic interests of all social sectors and a change in the production mode and lifestyles of the people, as well as the existing mode of thinking. Transforming any social system demands long-term and unremitting efforts better embraced in the education system.

Under such challenging conditions the correct understanding and handling of the links between the colonial legacy, planned economy and market regulation is crucial. Zimbabwe's higher education system therefore has to embrace a research and verification based process of aligning national attitudes and understanding towards sustainable socio-economic growth.

Like in any other socio-economic setting, the above hypotheses and Mathematical Models are used here with full appreciation of their usefulness and their limitations as they are developed to cater for a wide scope, diversified levels and relatively complete disciplines to meet the needs of education and socio-economic development.

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